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Environmental Protection
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Municipal Environmental Research
Laboratory
Cincinnati OH 45268

Research and Development

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Project Summary

Use of Selected Sorbents and an Aqueous Film Forming Foam on Floating Hazardous Materials

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Research was conducted to determine the effects of sorbent materials and fire-fighting foam on containment, recovery, and vapor suppression of floatable hazardous material spilled on water.

The tests, which were performed at the U.S. Environmental Protection Agency's (EPA) Oil and Hazardous Materials Simulated Environmental Test Tank (OHMSETT), made use of the Clean Water, Inc., Harbour Boom and the Industrial and Municipal Engineering Swiss OELA III Skimmer. These devices were also used in a 1975 EPA study, and results of both test programs are compared in this report.

Critical tow speed of the boom (speed at which hazardous material loss began), fluid recovered by the skimmer, and hazardous material vapor concentration were measured as functions of type of material, tow speed, type of sorbent, presence of foam, and wave condition. Test results were evaluated by comparing them with those obtained using pure hazardous material (i.e., no sorbent or foam).

Dioctyl phthalate (DOP), octanol, and naphtha served as the hazardous materials. The sorbent materials were polyurethane foam cubes; Clean Water, Inc., Sorbent C; and Dow Chemical Co. Imbiber Beads. An aqueous film forming foam (AFFF), FC-206*, from the 3M Company was used.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Large quantities of hazardous materials (HM) are constantly being handled by inland and marine tranportation and support equipment. Spills during transit or at producer and user storage facilities pose a serious threat to the health and welfare of the general public and environment. The study summarized here investigates the possibility of enhancing present containment and recovery techniques for spills of floating, immiscible HM. Several concepts were considered feasible:

1. Increasing the cohesiveness of spilled HM to stave off shedding and splash-over losses from a boom (see Figures 1 and 2),
2. Absorbing the HM into a more buoyant material to reduce sub-

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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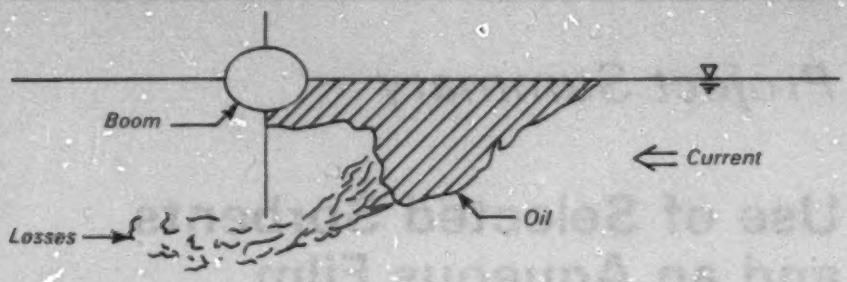

Figure 1. Hazardous material shedding failure and entrainment under a boom.

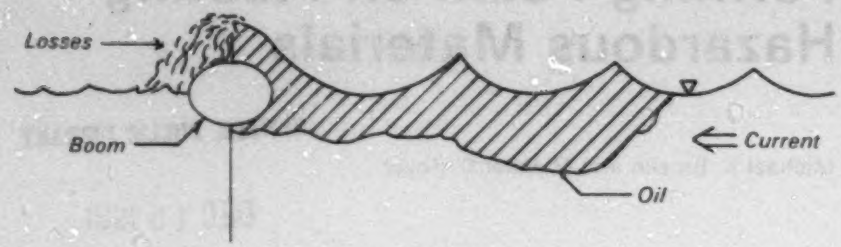

Figure 2. Hazardous material splash-over failure over a boom.

mergence and shedding beneath a boom, and

3. Covering the sorbent and hazardous material with fire-fighting foam to decrease HM vapors above the slick.

The purpose of this project was to investigate the effectiveness and practicality of the above-mentioned concepts in a simulated field-environment. Tests were performed at the OHMSETT facility with the use of three sorbents (foam cubes, Sorbent C, and Imbiber Beads) and fire-fighting foam in conjunction with the Clean Water, Inc., Harbour Boom and the Industrial and Municipal Engineering (IME) Swiss OELA III Skimmer on simulated spills of three hazardous materials (octanol, naphtha, and dioctyl phthalate). The critical tow speed of the boom, the amount of fluid recovered by the skimmer, and the HM vapor concentration above the slick were measured as functions of type of HM, tow speed, type of sorbent, pressure of foam, and wave condition. Test results were evaluated by comparing them with those obtained using pure HM (i.e., no sorbent or foam).

Test Plan

To compare the tests conducted in this program with the 1975 hazardous materials program, a test matrix was written to duplicate the previous program with the addition of sorbents and fire-fighting foam. Control tests without sorbents or foam were conducted for a basis of comparison with the 1975 tests. As the program proceeded, certain tests were eliminated from the matrix. The test with sorbent and AFFF in the harbor chop mode were deleted, as were tests employing the diversionary configuration of the boom.

Equipment

The OHMSETT is located in Leonardo, New Jersey, and is operated by EPA. The primary feature of the facility is a pile-supported, concrete tank that is spanned by a bridge capable of towing floating equipment. The principal systems of the tank include a wave generator, a beach, and a filter system. The wave generator and absorber beach can produce regular waves as well as a series of high-reflecting, complex waves meant to simulate the water surface of a harbor or the sea. The tank water is clarified by recirculation through a filter system to permit full use of a sophisticated underwater photography and video imagery system.

The Clean Water, Inc., Harbour Boom was essentially the same boom used in the 1975 tests; however, the skirt depth was increased from 57 to 61 cm, and the length was shortened from 60.5 to 40.5 m. The ends of the boom were bolted to the tow points of the main bridge, forming a catenary configuration under tow.

The IME Swiss OELA III Skimmer was selected for this test because of its use in the 1975 test and its availability.

A double-diaphragm, Warren Rupp Sandpiper pump (Model SA-3A, Type DA2-A) was used until clogging problem occurred. A 5.1-cm inlet/outlet Barnes rotary pump was subsequently employed. Except for priming problems when the skimmer emptied, it performed satisfactorily without clogging.

Clean Water, Inc., Sorbent C is a fibrous, oil-absorbing material that is buoyant in water even when fully saturated with oil. This material is comparable with that used in acoustic ceiling tiles. Sorbent C is supplied shredded and contains a considerable amount of fine dust. Dow Chemical Co. Imbiber Beads are 7-mm spheres of cross-linked, t-butylstyrene polymer that absorb and retain hydrocarbons. The beads are oleophilic, hydrophobic, and very buoyant.

The foam sorbent consisted of 1.9-cm cubes of reticulated, open-cell, 31 pore/cm, quenched polyurethane. This type of foam cube was found to be durable and effective in absorbing hydrocarbons in previous tests at OHMSETT.

A gasoline-engine-powered centrifugal blower with a 3-m long, 20-cm-diameter flexible hose was used to apply the Sorbent C, Imbiber Beads, and foam cubes. Originally, a rotary lawn fertililzer (vertical spreader axis) was used to distribute the Imbiber Beads by connecting a 1/4-inch variable speed drill to the wheel axle. The centrifugal blower distributed beads farther and at a greater rate.

FC-206, an aqueous film-forming foam (AFFF) produced by 3M Company, was employed. A standard mixing nozzle connected to a fire hose produced a stream that shot about 6 m and formed a 7.6-cm-thick blanket of foam.

The hazardous materials selected for testing (naphtha, DOP, and octanol) represented a wide range of three important physical properties—viscosity, specific gravity, and interfacial tension. They were also selected for their low toxicity and flammability. The same fluids were used in the 1975 test program, but in larger amounts (1.325 m^3 per test versus 0.38 m^3).

Cameras provided visual documentation of test layout, equipment, and

performance characteristics. A black and white TV camera in a waterproof case with a video recorder provided underwater coverage. Two 16-mm movie cameras and a 35-mm slide camera were employed for topside and tankside window coverage.

To detect and determine vapor concentration, a Miran 1A Gas Analyzer and an Esterline Angus Mini-Servo strip-chart recorder were used with two filtered air intakes. One was mounted on the main bridge just above the water, and the other was positioned on the auxiliary bridge on a pivot mount that could be swung to follow the boom apex. Two 1/2-inch (12.2 cm) valves were used to switch from one intake to the other.

Test Procedures

The boom was connected to the towing bridge and set in motion at 0.5 kt.

The HM, stored in tanks on the main bridge, was distributed into the boom from the front of the main bridge. As the test continued, sorbent and/or foam was distributed onto the slick as it was passed over by the rear side of the bridge. The boom speed was increased until failure (i.e., HM loss from the boom) was observed, decreased until failure ceased, and then increased again to confirm the failure speed. This speed was recorded as the critical tow speed. (When DOP was used as the HM, the tow speed had to be decreased below 0.5 kt for the critical tow speed determination.) Certain tests were repeated with the same charge in the boom to observe the effect of longer mixing and absorption time.

Sorbent C and foam cubes were distributed until about three-fourths of the slick was covered, which required 16.36 kg of Sorbent C and 0.22 m^3 of foam cubes. For Imbiber Bead application, a 1:10 ratio was used with DOP and octanol, and a 1:20 ratio with naphtha. The fire-fighting foam was distributed until the slick was covered.

Following boom tests with Sorbent C and Imbiber Beads, skimmer tests were conducted. The HM/sorbent in the boom was directed to the skimmer with fire hoses, and the recovered material was pumped to polyethylene collection barrels. After a sufficient settling period (2 hr), liquid levels in the barrels were measured. The sorbent and HM were mixed, sampled, and analyzed for oil, water, and solid content.

The use of sorbents prevented the continuous flow of HM into the skimmer during calm water tests and necessitated the use of a boat hook to keep the skimmer weir submerged. Because of potential clogging problems, it was not feasible to use the skimmer to collect the foam cubes. Instead, they were recovered by nets after the test and hydraulically squeezed for reuse in subsequent tests.

The HM vapor was continuously sampled and analyzed for hydrocarbons during each test. The sample intake on the main bridge was used when the HM was initially distributed. After the foam and/or sorbent had been applied, the sample was drawn from the intake on the auxiliary bridge over the boom apex. The two readings were compared to measure sorbent/foam effects on HM evaporation.

Results

Results of the boom tests are summarized in Figures 3 through 7. The effects of sorbents and foam on critical tow speed are clearly indicated. In addition, the boom performance on pure HM may be compared with the 1975 test results.

For pure HM, higher critical tow speeds were measured in these tests than in 1975. This result can be attributed to the larger amount of HM used in 1975, to the different method of attaching the boom to the towing bridge, and to the subjective decisions on the degree of HM loss constituting boom failure.

The foam cubes increased the critical towing speed substantially for both DOP and naphtha, but then had little effect with the octanol (see Figures 3 through 5). The spaces between the cubes tended to trap the HM and prevent shedding. Through the subsurface windows, it was seen that the underwater portion of the cubes prevented the interfacial shearing force from reaching the HM.

The results obtained when employing Sorbent C showed an increase in the boom's ability to retain HM. The suspension of fibers in a liquid can reduce turbulent drag, which causes the formation and release of oil droplets at the oil/water interface. The product also acted as a buoyant sorbent that prevented shedding.

The Imbiber Beads performed best on DOP and worst on naphtha. Given enough Imbiber Beads and a sufficient residence time, the HM slick could have been made into a solid buoyant sheet. Such a procedure would be impractical in field use, however, because of the large number of beads required.

Some test results indicated that a higher critical tow speed is attainable

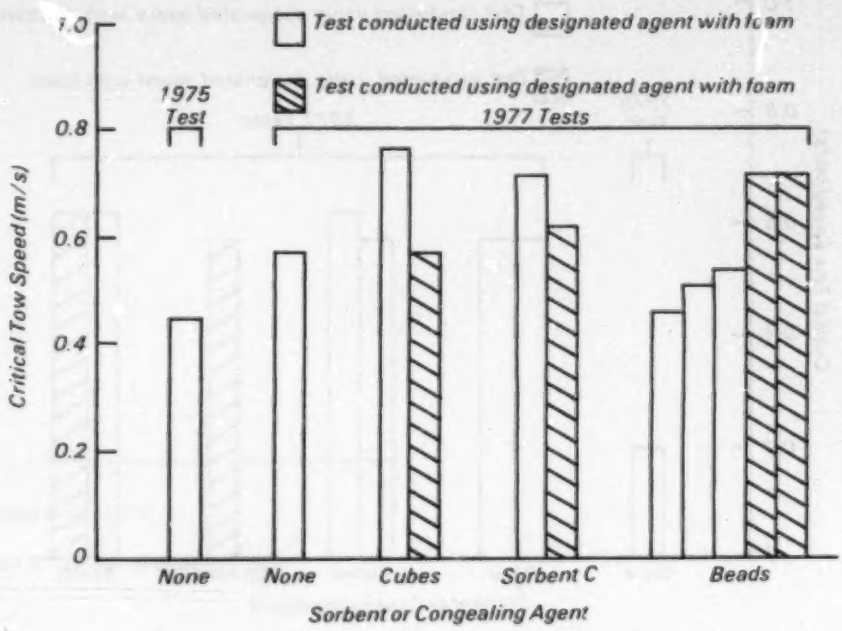

Figure 3. Clean Water boom performance in calm water using naphtha.

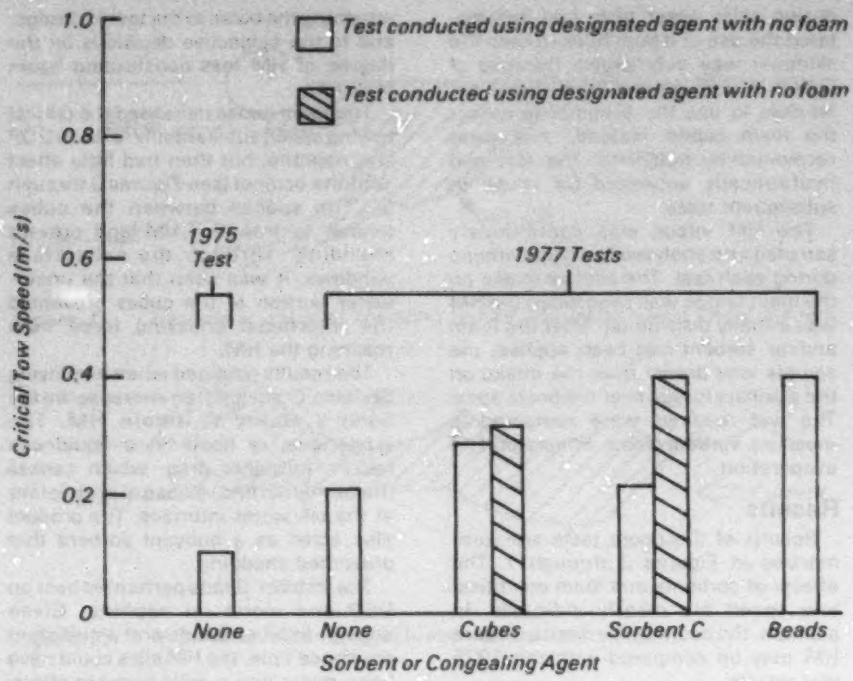

Figure 4. Clean Water boom performance in calm water using DOP.

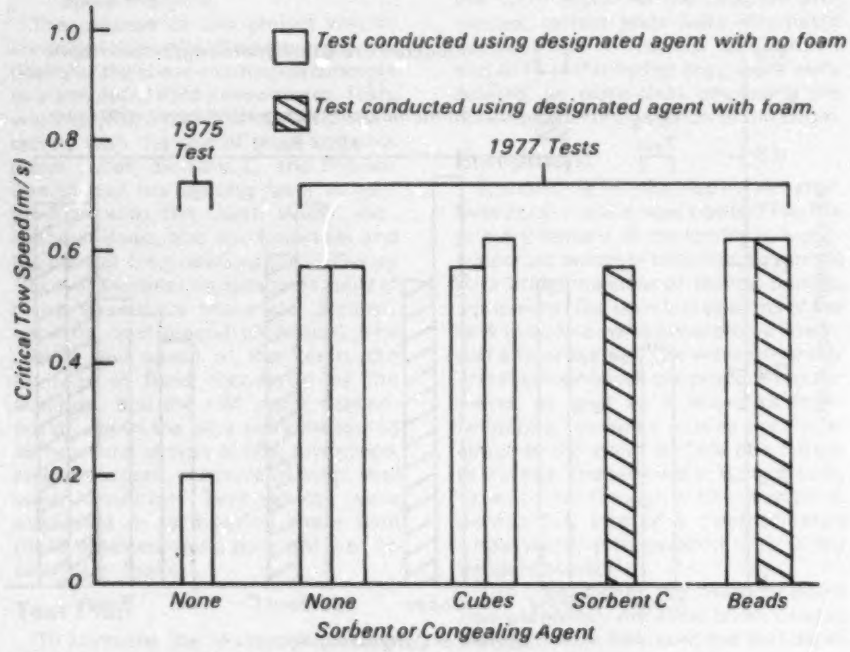

Figure 5. Clean Water boom performance in calm water using octanol.

using AFFF and sorbent rather than sorbent alone. Perhaps the foam causes the sorbent to become wetter or to absorb more oil.

The results obtained using the IME skimmer are very operator-dependent, which makes an overall comparison of the tests difficult. The use of sorbents did substantially reduce HM and water emulsification. The skimmer test with pure octanol resulted in a water content of 26%. Water contents in samples from test runs with Sorbent C and Imbiber Beads were 3.6% and 7.25%, respectively.

DOP and octanol have low vapor pressures. The differences in vapor concentration at the two sample points were very small and were far outweighed by the experimental variations resulting from wind and temperature effects, filter clogging and contamination, and shape of slick. The naphtha results consistently indicate that the vapor concentration above the slick was higher following the addition of sorbent; but the results do not necessarily indicate that the addition of the sorbent was the cause of the increase. Thus, no conclusions were drawn from the vapor concentration studies.

Conclusions

The following conclusions were drawn from the evaluation of the test data and observations of equipment performance:

1. Introducing sorbents or congealing agents into the HM enables a stable boom to contain the material at a higher current velocity or tow speed in calm water.
2. The polyurethane foam cubes were most easily distributed and accounted for later.
3. To optimize the effect of sorbents, time for mixing and absorption of HM must be allowed. The time required varies with wave condition and turbulence.
4. Because of splash-over failure, neither the sorbents nor the Imbiber Beads enhanced containment in the presence of 0.3-m harbor chop.
5. Application of sorbents to a floating HM spill is possible with the use of a simple blower-type distributor, such as those used to distribute wood chips or straw in landscaping operations.
6. Cleanup effort (e.g., sorbent acquisition, transportation, distribution, collection, separation, recycling, and

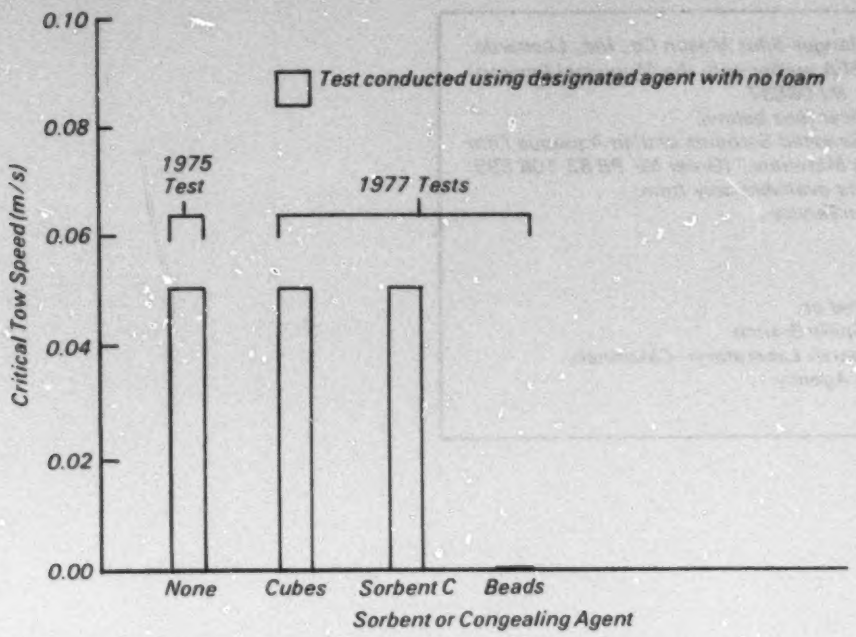

Figure 6. *Clean Water boom performance in harbor chop using naphtha.*

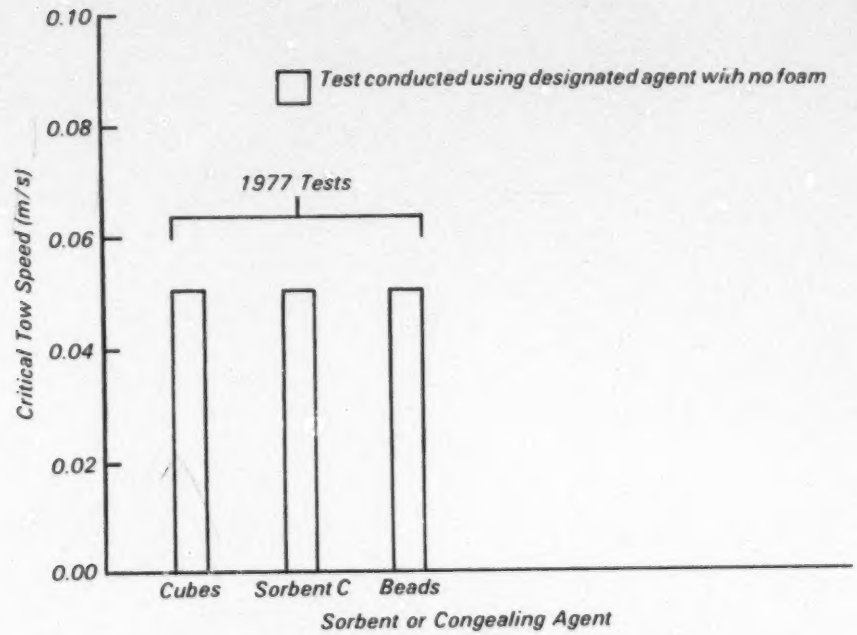

Figure 7. *Clean Water boom performance in harbor chop using DOP.*

disposal) was substantially increased as a result of the use of sorbents.

7. Some test results indicate that a higher critical tow speed is attainable using AFFF and sorbent rather than sorbent alone.

Recommendations

Careful study should be given to the safety aspects and the disposal, storage, and refurbishing of sorbents used to recover HM. Although the concentration of vapors above an HM slick does not increase appreciably when solvent is added, the HM will rapidly evaporate from the sorbent after recovery, creating an air pollution or explosion hazard.

Although the polyurethane foam material was not expensive ($0.50/m^3), the cutting of the cubes was. Use of a larger cube is therefore recommended to decrease cube-cutting costs.

The resource costs associated with acquisition, transportation, distribution, collection, separation, recycling, and disposal of sorbents are significant and must always be considered before using sorbents to enhance floating HM recovery.

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__John S. Farlow__ is the EPA Project Officer (see below).
The complete report, entitled "Use of Selected Sorbents and an Aqueous Film Forming Foam on Floating Hazardous Materials," (Order No. PB 82-108 895; Cost: $8.00, subject to change) will be available only from:
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